

# **Utah Division of Air Quality**

## **Smoke from August 2015 Western Wildfires Exceptional Events**

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## Introduction

The Code of Federal Regulations (CFR) provides the definition and criteria for determining whether air quality data is impacted by an exceptional event. The 40 CFR 50.1(j) definition states that “exceptional event means an event that affects air quality, is not reasonably controllable or preventable, is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event.” The demonstration to justify data exclusion as outlined in 40 CFR 50.14(c)(3)(iv-v) specifies that evidence must be provided that:

1. The event meets the definition of an exceptional event;
2. The event is associated with a measured concentration in excess of normal historical fluctuations, including background;
3. There is a clear causal relationship between the measurements under consideration and the event that is claimed to have affected air quality in the area;
4. There would have been no exceedance or violation but for the event; and
5. The demonstration must include a public comment process and documentation of such to the Environmental Protection Agency (EPA).

This report provides documentation that the PM<sub>2.5</sub> violations that occurred in August, 2015 were the result of exceptional events and that these events meet the criteria for data exclusion under the Exceptional Events Rule, as described above. The violations were a direct result from smoke from western regional wildfires caused by natural events that occurred outside of Utah jurisdictional boundaries thus, were not reasonably controllable or preventable.

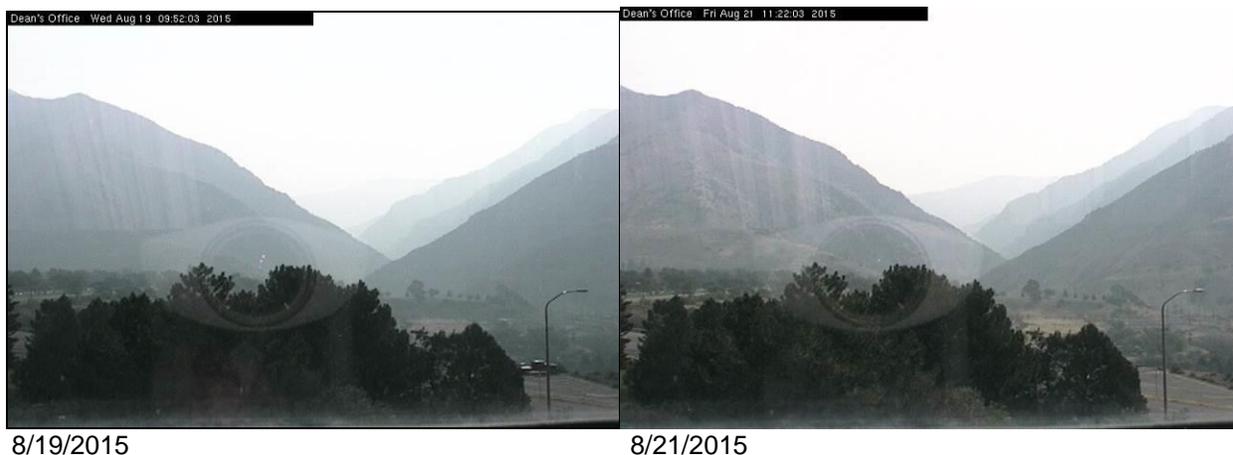
## Event Description

Excessive hot and dry conditions across western states lead 2015 to be another severe wildfire year. Wildfire smoke was visible in portions of the Wasatch Front and Cache Valley starting on August 16, 2015.



On August 18, 2015, the National Weather Service (NWS) stated that “large fires in Washington, Oregon, Idaho and Montana, combined with northwest flow has made the skies hazy across Utah and Colorado.” Approximately 70 wildfires were burning during this event period in the western states. The National Interagency Fire Center reported on August 23, 2015 that over a million acres had burned.

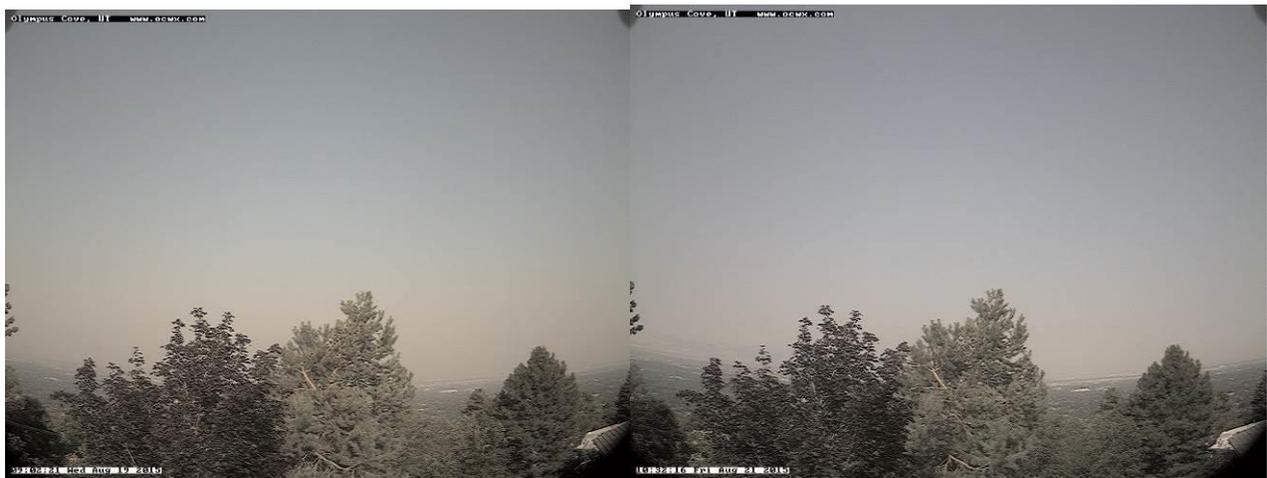
Persistent smoke in Logan Canyon can be seen from these photos taken on August 19 and 21.



Photos taken in South Ogden on the 19<sup>th</sup> and 21<sup>st</sup>, similarly show persistent smoke.



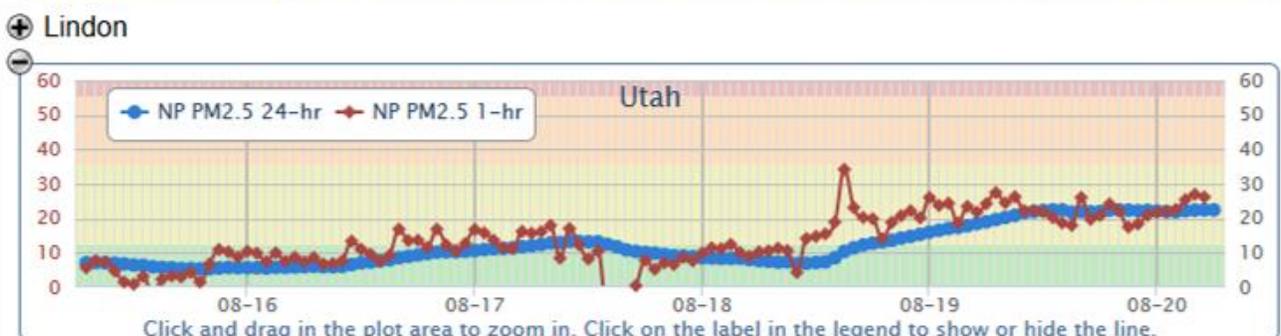
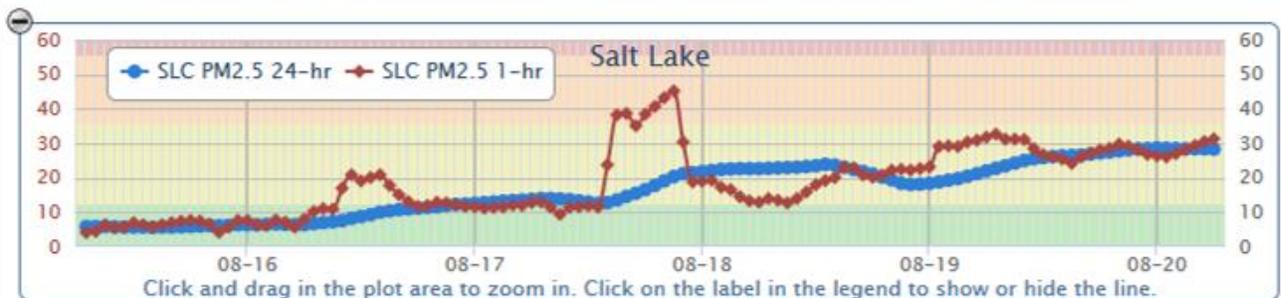
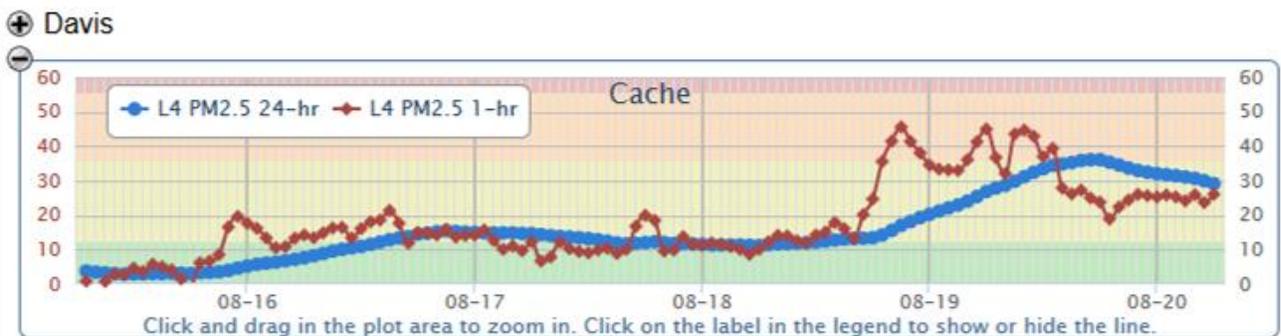
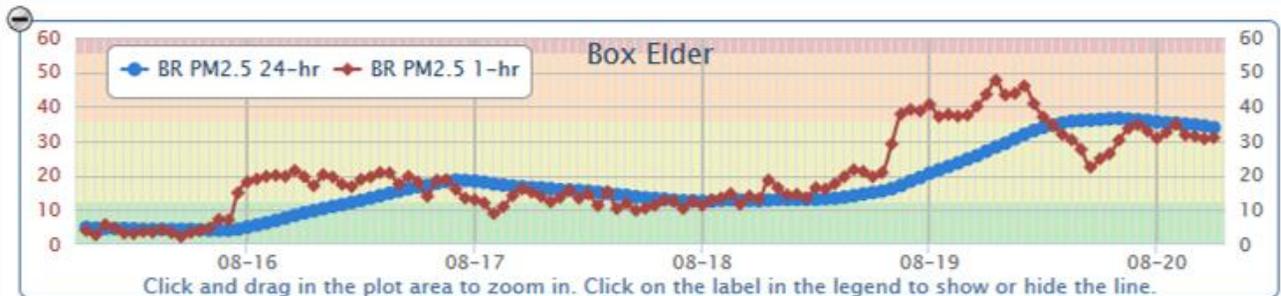
The following photos taken from Olymous Cove show the presence of smoke in the Salt Lake Valley on the 19<sup>th</sup> and 21<sup>st</sup>.

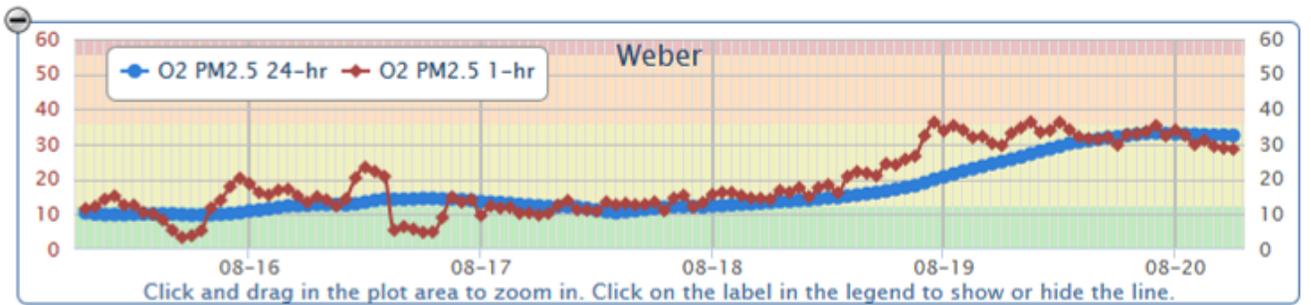
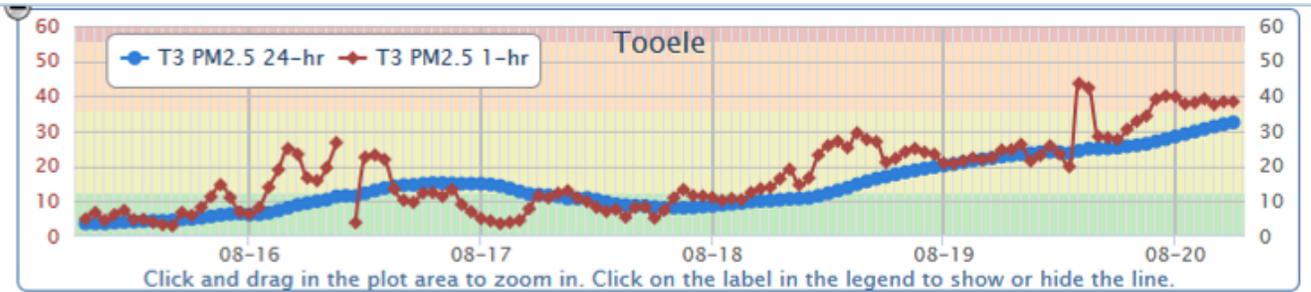


## Air Quality Impact

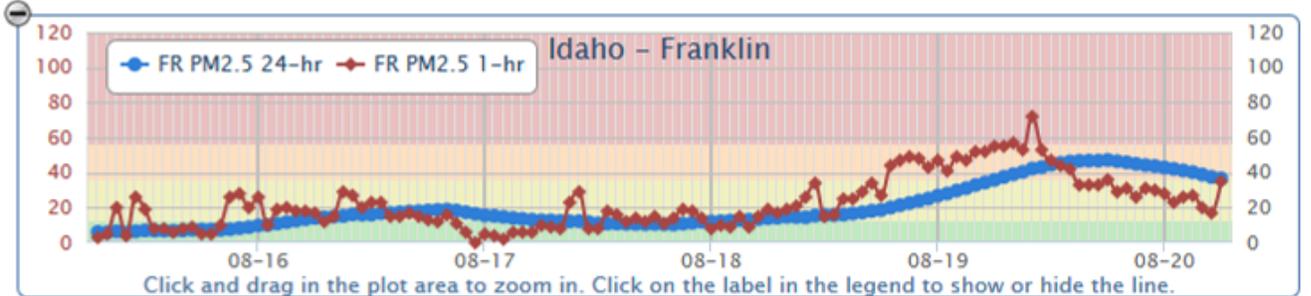
Wildfire smoke arrived in Utah on the 17<sup>th</sup>. The trend charts show low PM<sub>2.5</sub> values on the 16<sup>th</sup>, with creeping values on the 17<sup>th</sup>.

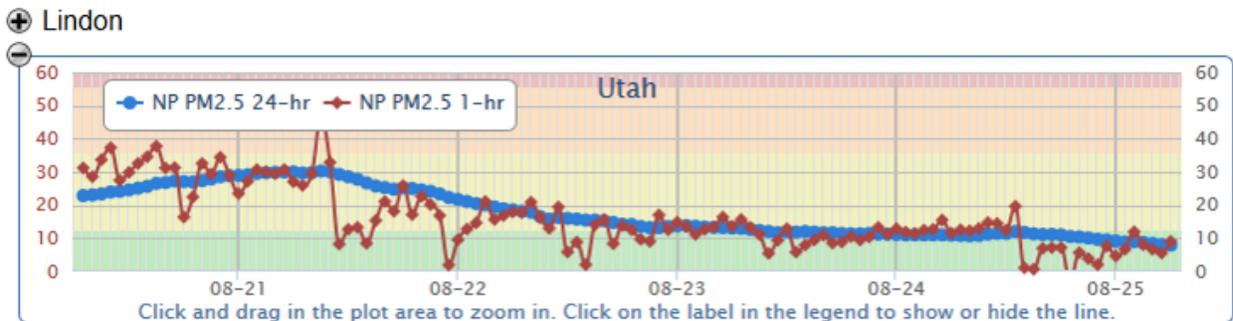
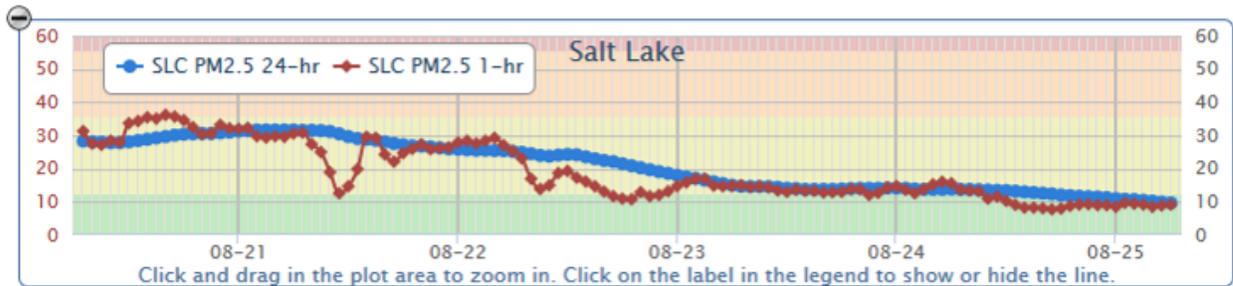
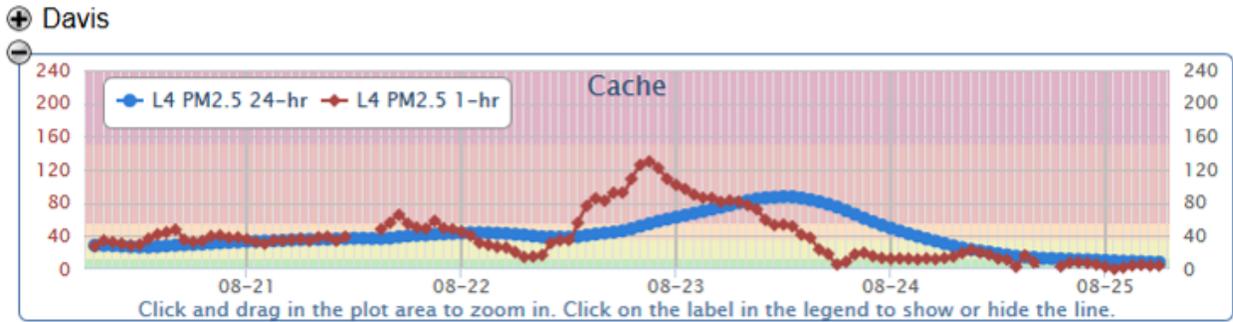
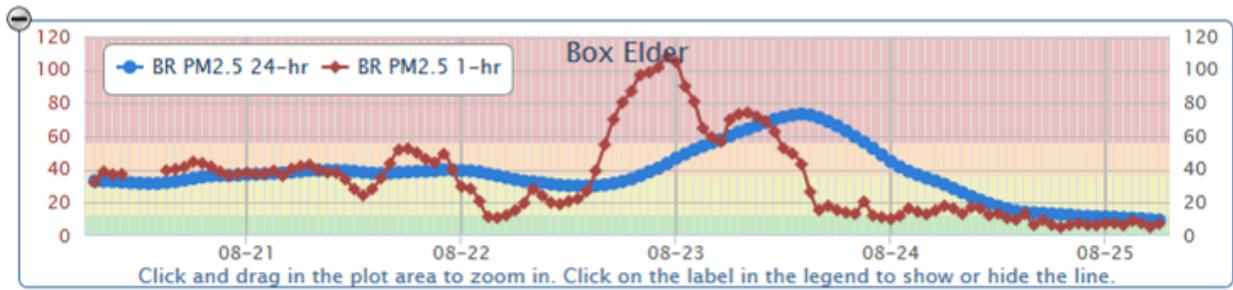
Smoke dispersion was hampered by low to stagnant wind conditions from the 16<sup>th</sup> to the 22<sup>nd</sup>. A shift in the upper atmospheric wind patterns late on the 23<sup>rd</sup> reduced incoming smoke. Some localized surface winds on the 23<sup>rd</sup> also helped disperse resident smoke.

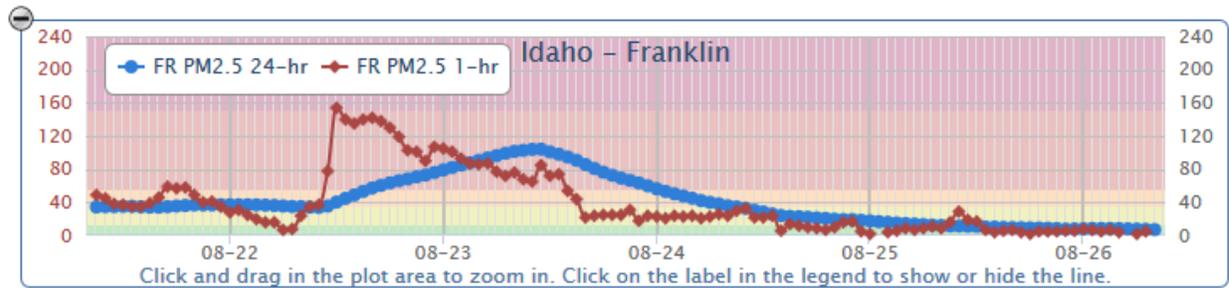
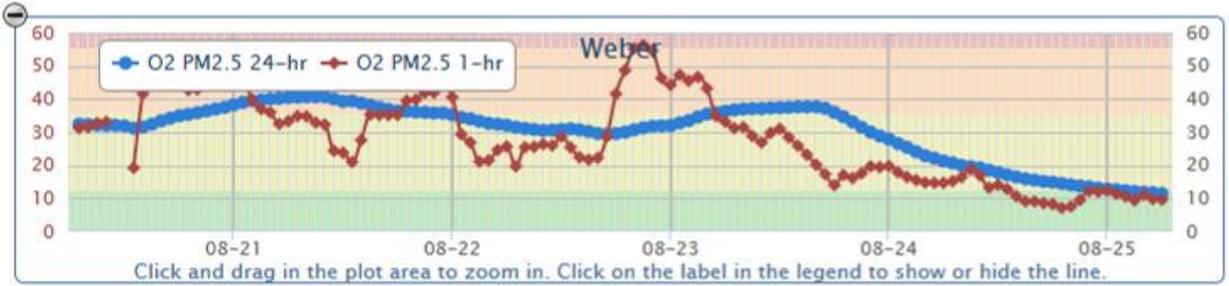
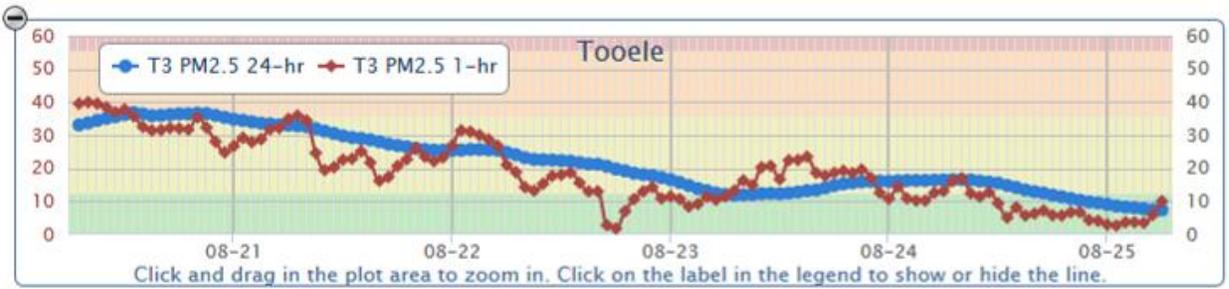




- + Duchesne
- + Washington







The PM<sub>2.5</sub> standard of 35 µg/m<sup>3</sup> is based on a 24-hr average. The following violations of that standard occurred by averaging hourly values:

Brigham City Monitoring Station

August 19, 2015: 35.6 µg/m<sup>3</sup>

August 20, 2015: 37 µg/m<sup>3</sup>

August 21, 2015: 39.5 µg/m<sup>3</sup>

August 22, 2015: 46.8 µg/m<sup>3</sup>

August 23, 2015: 44.8 µg/m<sup>3</sup>

Site: Brigham City					
Units	UG/M3				
Date	19-Aug	20-Aug	21-Aug	22-Aug	23-Aug
Hour					
0:00	37.1	32.6	37.2	28.4	90.1
1:00	37.8	34.9	37.5	20.9	81
2:00	37.2	31.8	39.3	11.5	64.9
3:00	37.6	31.5	36.2	10.9	59.5
4:00	40.1	30.7	40.4	12.4	56.8
5:00	43.6	31	41.9	15.4	70.1
6:00	47.7	32.4	42.8	19.7	73.3
7:00	43.4	38.6	39.9	28.2	74.3
8:00	43.9	37	38.2	24.3	71.9
9:00	46	37.1	38	20.1	69.1
10:00	40.9	<	34.1	19	62.8
11:00	37	<	28.3	21	52.9
12:00	34.6	<	24.4	22.4	49.6
13:00	32	<	28.3	26.9	43.1
14:00	30.4	39.5	34.8	39.2	26.4
15:00	27.6	40.2	43.5	54.9	15.6
16:00	22.5	41.4	51.9	70.2	18.1
17:00	24.9	44.6	52.6	80.4	15.5
18:00	26.4	43.7	50.1	87.2	14
19:00	30.3	41.7	46.3	96.9	13.2
20:00	33.7	38.7	44.1	98.5	20.5
21:00	34.8	36.3	49.3	101.6	12.2
22:00	33	37.3	39.9	107.9	11.2
23:00	30.9	38	29.7	104.7	10.2
<b>Avg</b>	<b>35.6</b>	<b>37</b>	<b>39.5</b>	<b>46.8</b>	<b>44.8</b>

Logan Monitoring Station

August 21, 2015: 43.7 µg/m<sup>3</sup>

August 22, 2015: 62.9 µg/m<sup>3</sup>

August 23, 2015: 49.6 µg/m<sup>3</sup>

Site: Logan			
Units	UG/M3		
Date	21-Aug	22-Aug	23-Aug
Hour			
0:00	32.9	40.9	96.8
1:00	31	32	90.2
2:00	34.7	29.5	86.2
3:00	34.7	26.9	86
4:00	35.6	26.2	81.1
5:00	36.8	20.8	82.9
6:00	34.6	14.9	81.6
7:00	38.4	15.2	77.2
8:00	39.2	17.1	72.4
9:00	34.5	31.8	59.5
10:00	39.2	34.9	53.2
11:00	<	35.3	53.9
12:00	<	56	51.9
13:00	<	76.5	41.7
14:00	48.5	85.7	38
15:00	56.2	82.6	24.1
16:00	65.7	92.4	18.6
17:00	55.2	92.6	6
18:00	50.4	109.1	9.1
19:00	49.1	125.9	18.1
20:00	58.4	129.9	20
21:00	49.6	122	15.9
22:00	48.4	109.1	13.7
23:00	45.2	101.6	12.8
<b>Avg</b>	<b>43.7</b>	<b>62.9</b>	<b>49.6</b>

Ogden Monitoring Station

August 20, 2015: 38.3  $\mu\text{g}/\text{m}^3$

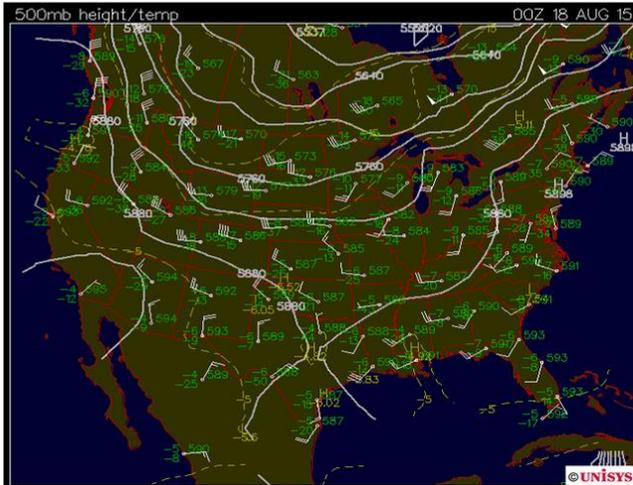
August 21, 2015: 35.3  $\mu\text{g}/\text{m}^3$

Site: Ogden		
Units	UG/M3	
Date	20-Aug	21-Aug
Hour		
0:00	32.6	47.8
1:00	29.9	39.8
2:00	31.1	37
3:00	29.4	36
4:00	28.9	32.5
5:00	28.6	33.3
6:00	31.2	34.9
7:00	31.6	34.8
8:00	32.7	32.9
9:00	33.1	32.3
10:00	<	24.4
11:00	<	23.8
12:00	19.2	21
13:00	41.6	27.6
14:00	49.2	35.3
15:00	51.8	35.2
16:00	50.8	35.2
17:00	46.8	35.2
18:00	42.7	39.5
19:00	42.9	39.8
20:00	44.8	41.9
21:00	47.6	41.9
22:00	44	44.5
23:00	52.2	40.6
<b>Avg</b>	<b>38.3</b>	<b>35.3</b>

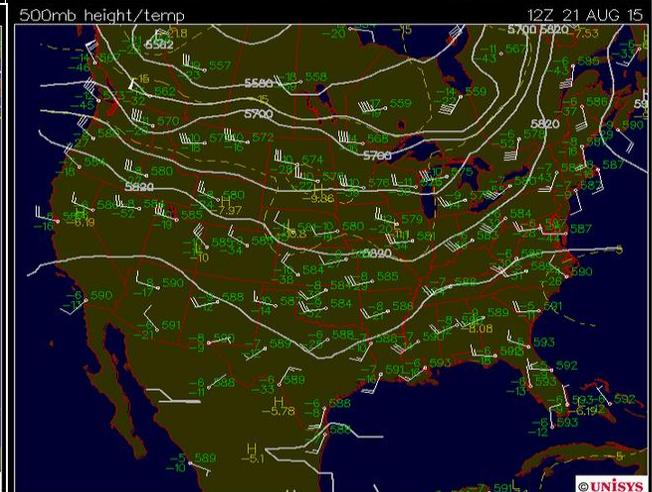
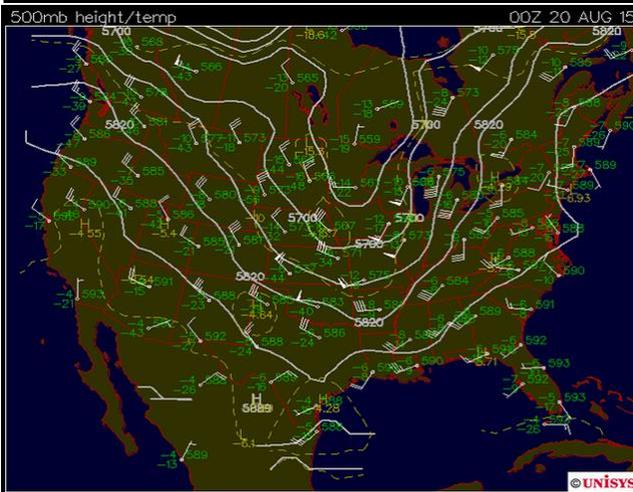
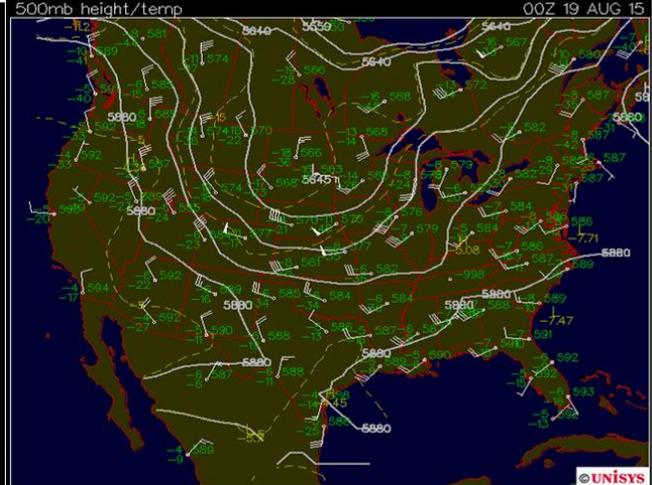
## Meteorology

The 500 MB constant pressure analysis illustrates the mid-level wind flow patterns. The contour lines on the 18<sup>th</sup> indicate smoke flow patterns were predominately from Idaho, Oregon and Washington to northern Utah. The same general flow pattern continued through the 20<sup>th</sup>.

August 18, 2015



August 19, 2015

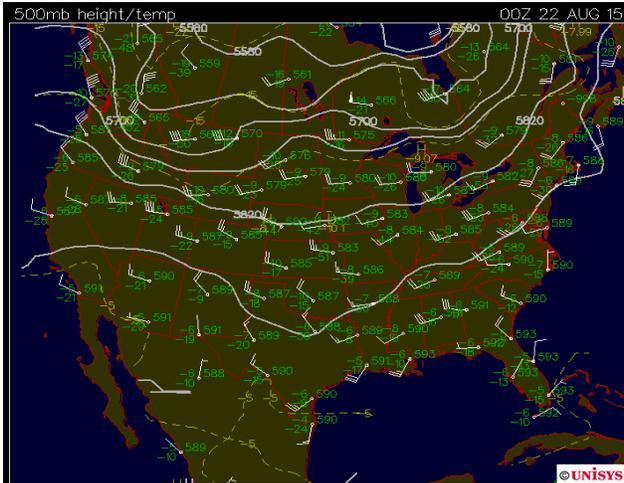


August 20, 2015

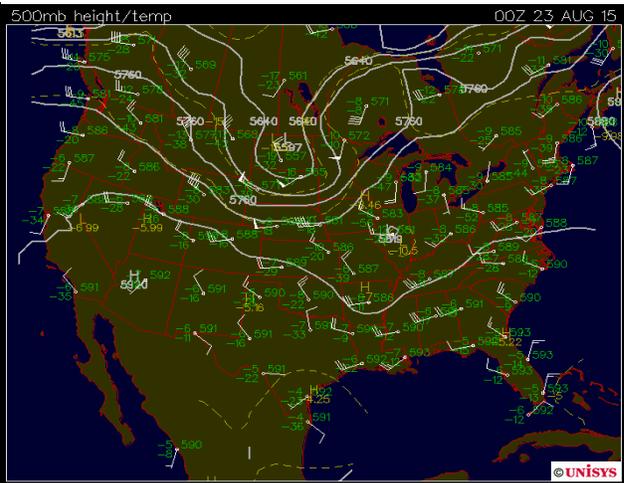
August 21, 2015

A pattern change began on the 21<sup>st</sup> and 22<sup>nd</sup>, with the approach of a trough from the northwest. As the trough moved in, the heights began to move south, creating a zonal flow pattern over the west. This pattern moved smoke more from the northern California fires to northern Utah. Progression of the trough inland was followed by rising heights along the west coast, with ridging driving the flow pattern more southeasterly (creating a funneling effect). This caused smoke patterns to drive towards northern Utah from California, Oregon, Washington and Idaho. The same funneling affect can be observed on the contour map for the 23<sup>rd</sup>.

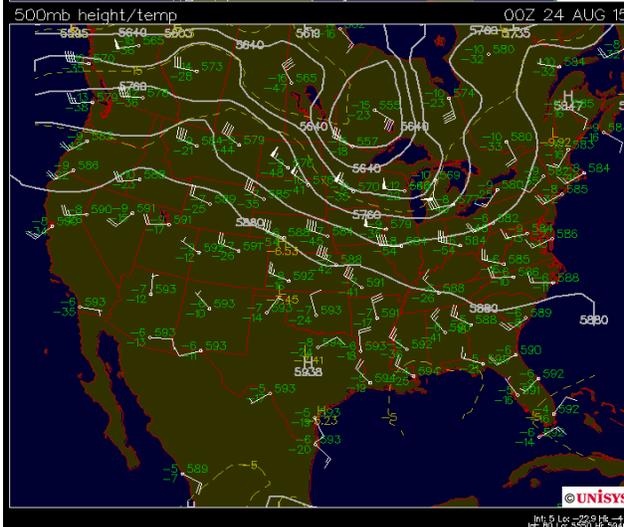
August 22, 2015



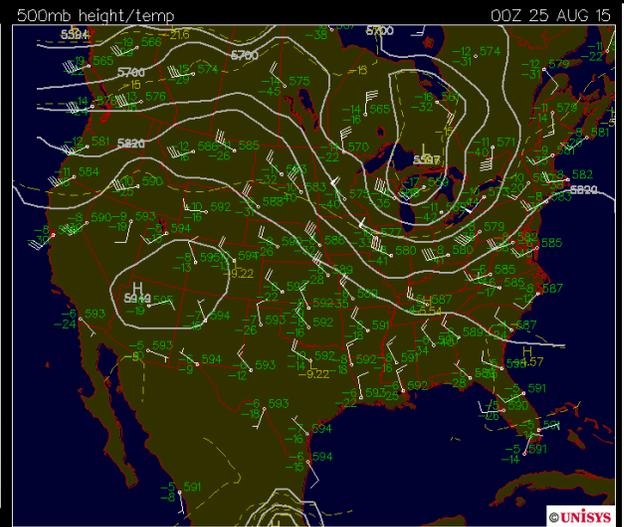
August 23, 2015



August 24, 2015

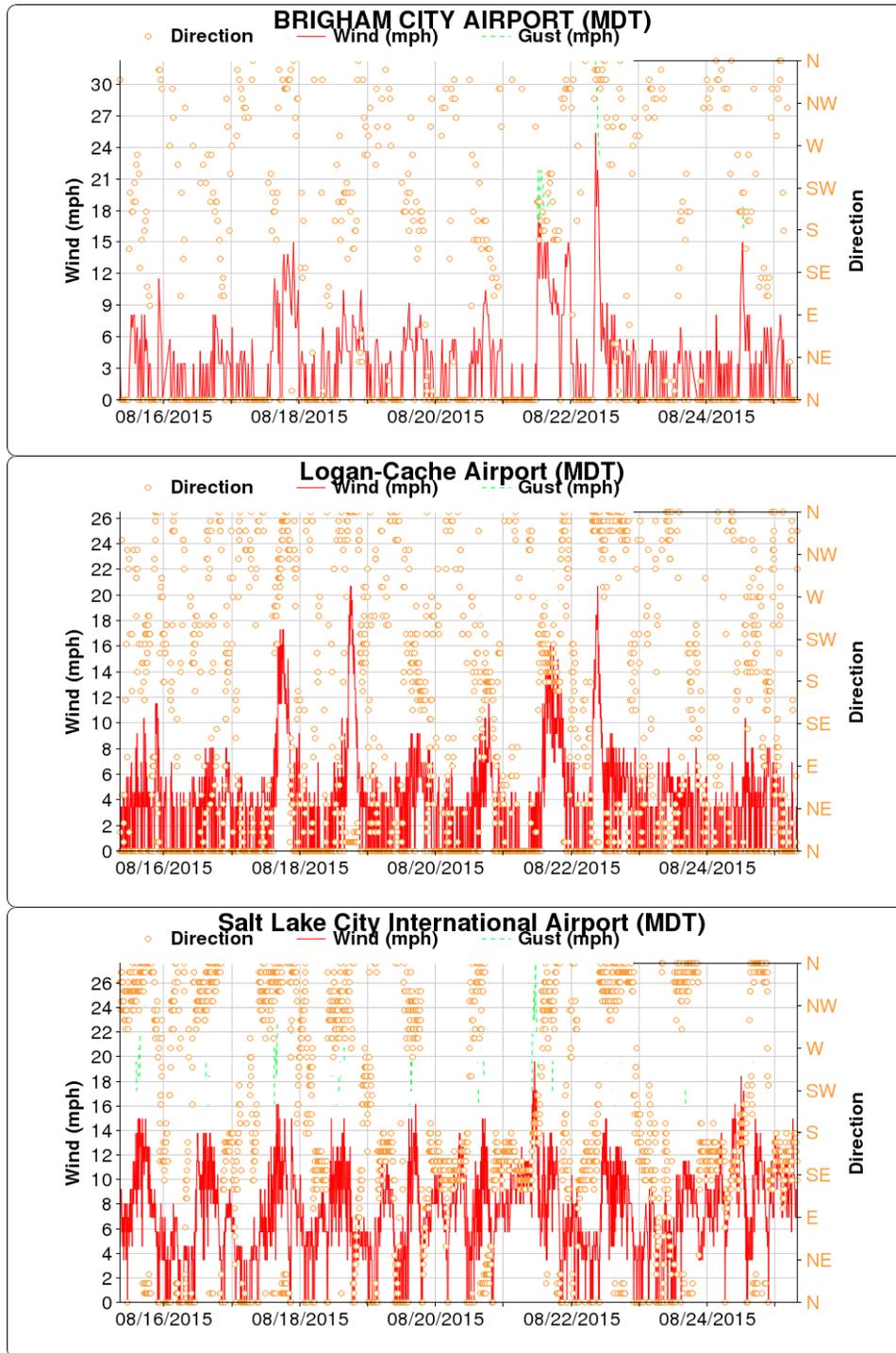


August 25, 2015



By the 24th and certainly the 25th, the mid-level winds were now mostly southwesterly over the western region, moving the smoke more northerly and northeasterly, away from northern Utah. Smokey conditions began to dissipate in northern Utah, with smoke being directed into Canada then into the Midwest.

Surface wind conditions plotted by MesoWest for the area airports, shows that there were low surface wind speeds for most of the event period at Brigham City and Logan. Low wind speed and close proximity to wildfires in surrounding states contributed to the highest measured PM<sub>2.5</sub> values.



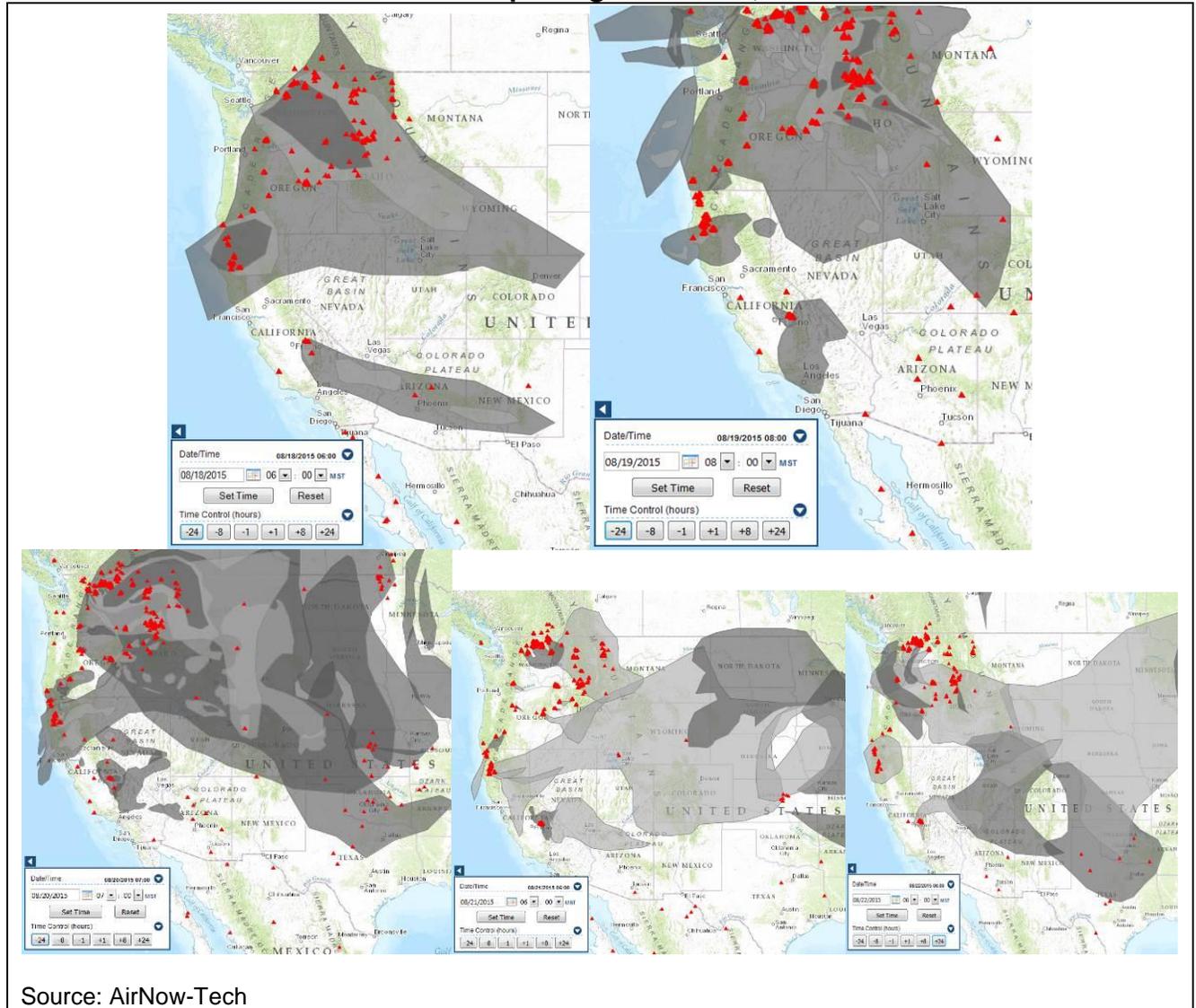
Salt Lake City airport data is substituted for the Ogden airport data because the Ogden data is not available. Fluctuating wind speeds in Salt Lake City helped disburse some smoke, especially on the 24<sup>th</sup>.

# Clear Causal Relationship

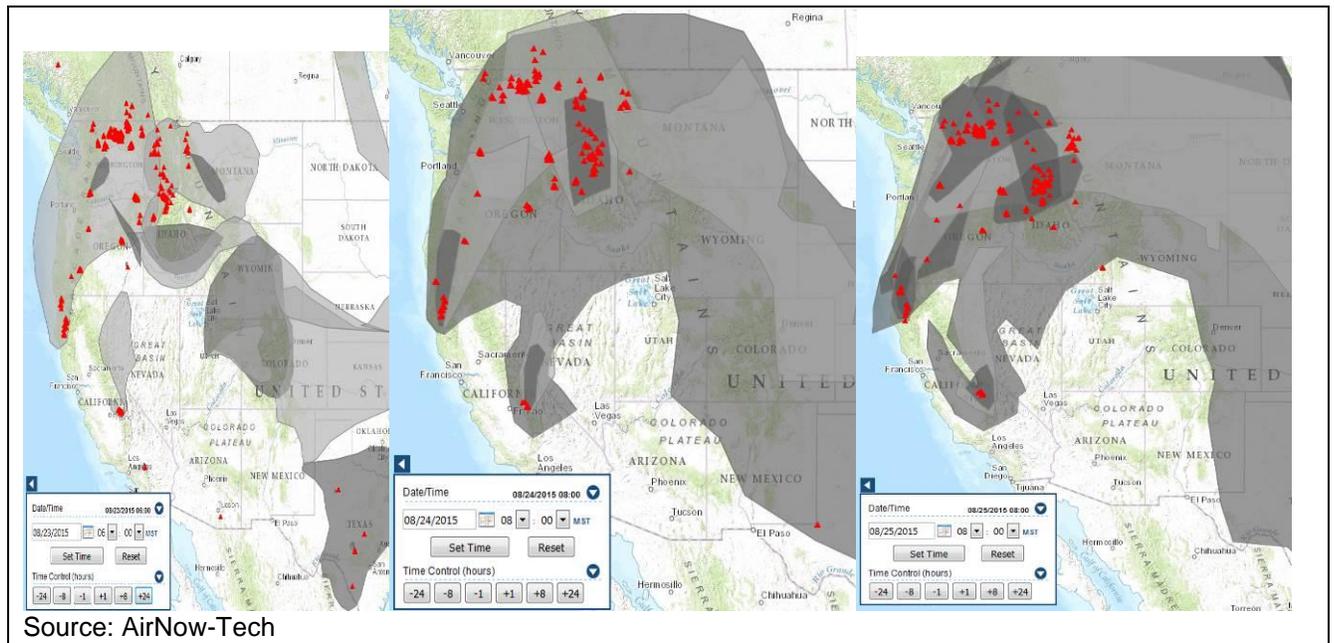
## Smoke Trajectory

Fire locations are noted in red markers and smoke plumes are in gray shading. Smoke contribution varied from multiple wildfires on a daily bases due to varying upper atmospheric transport patterns.

### Smoke Maps August 18 – 22, 2015



Source: AirNow-Tech

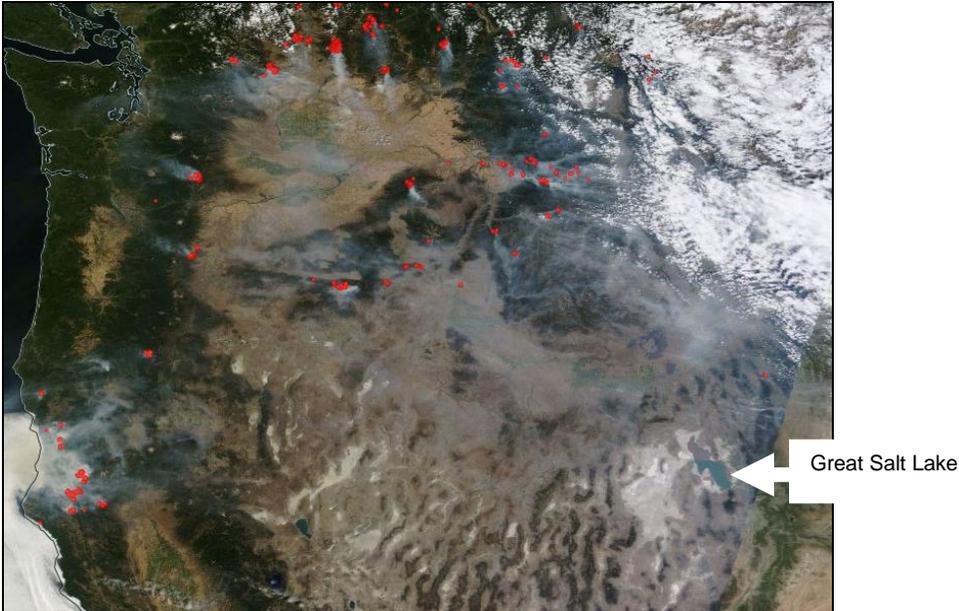


Source: AirNow-Tech

### Smoke Maps August 23 – 25, 2015

**Satellite Imagery**

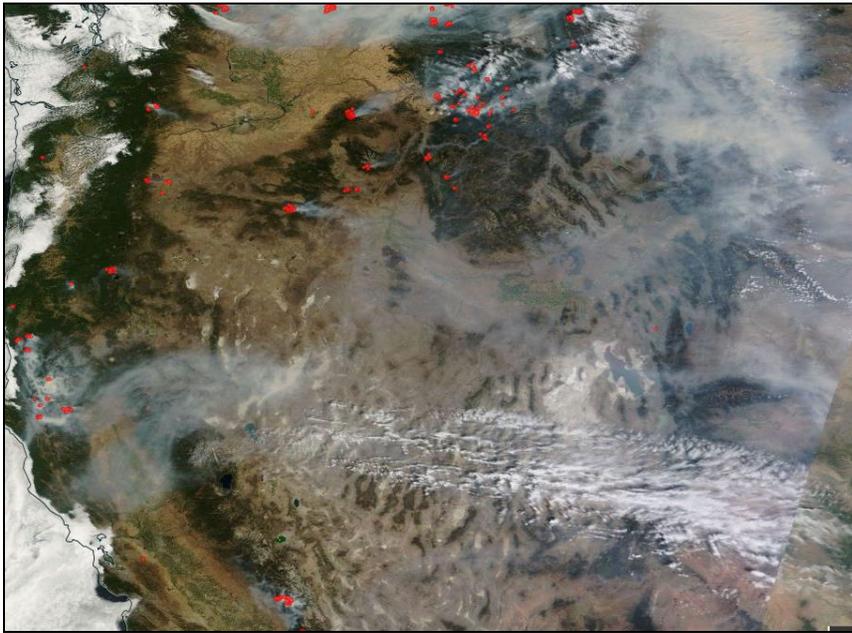
Smoke transport can be visibly verified with Modis satellite imagery. The red markers are the wildfire locations. The off-gray wisps are smoke plumes.



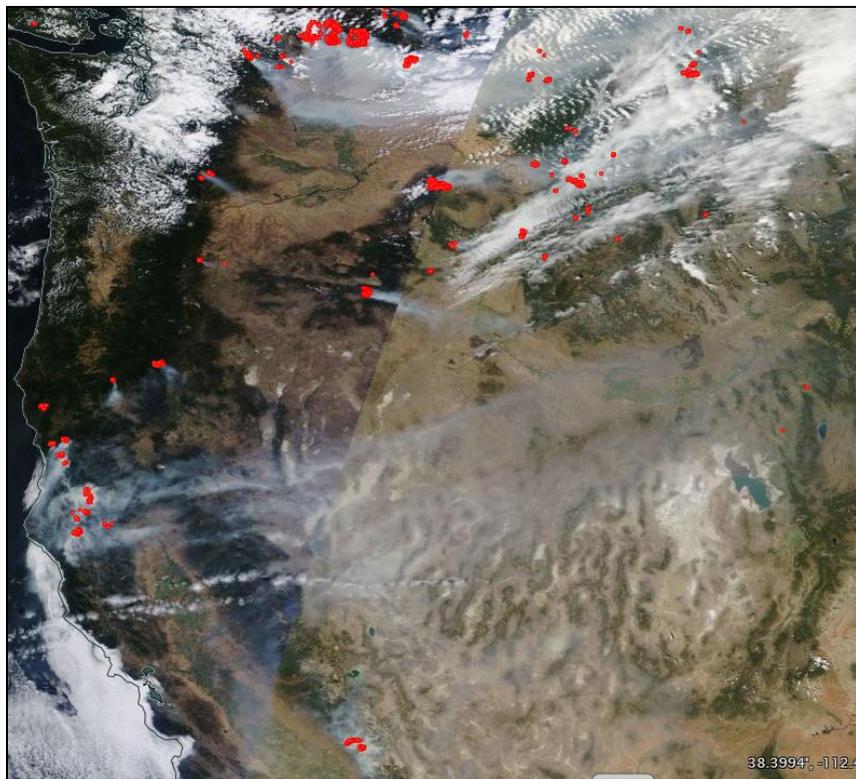
August 18, 2015



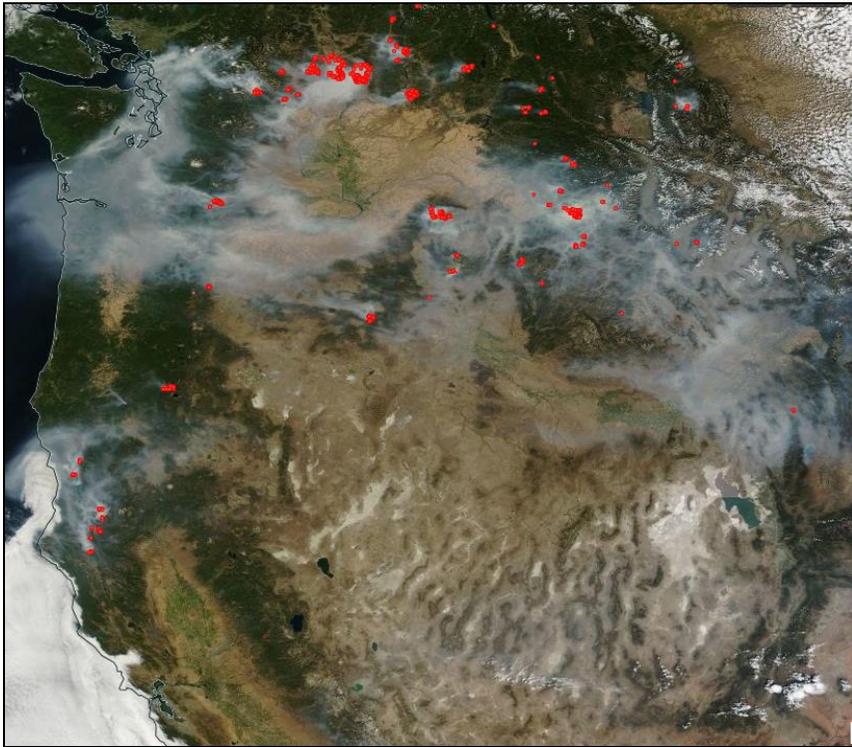
August 19, 2015



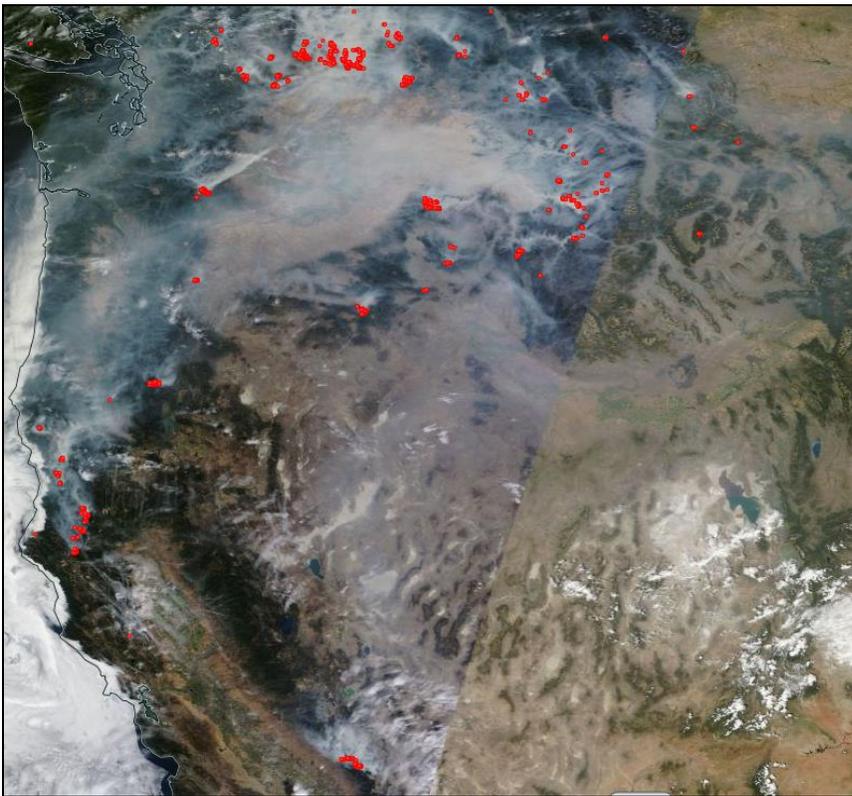
August 20, 2015



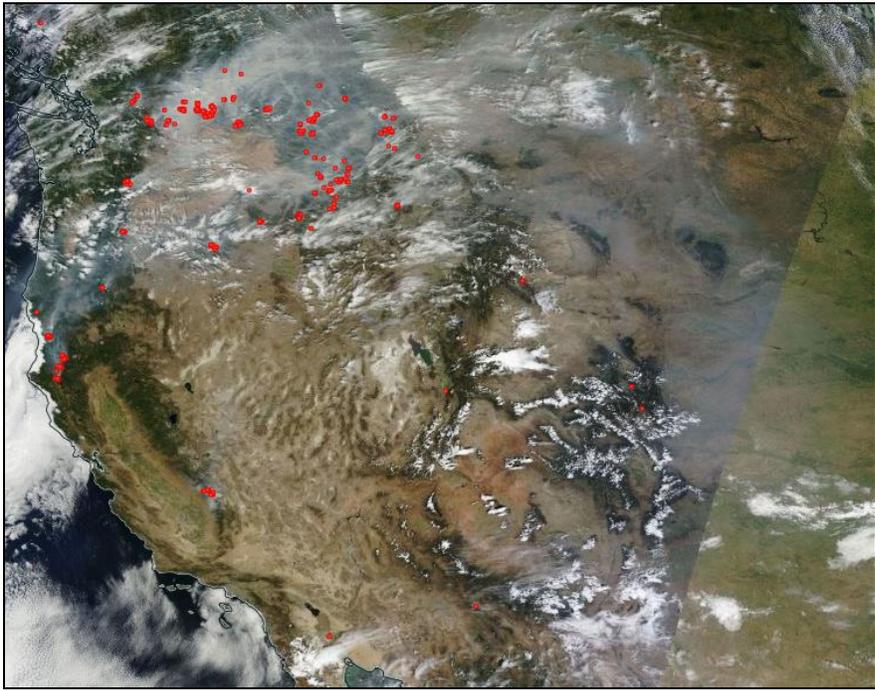
August 21, 2015



August 22, 2015



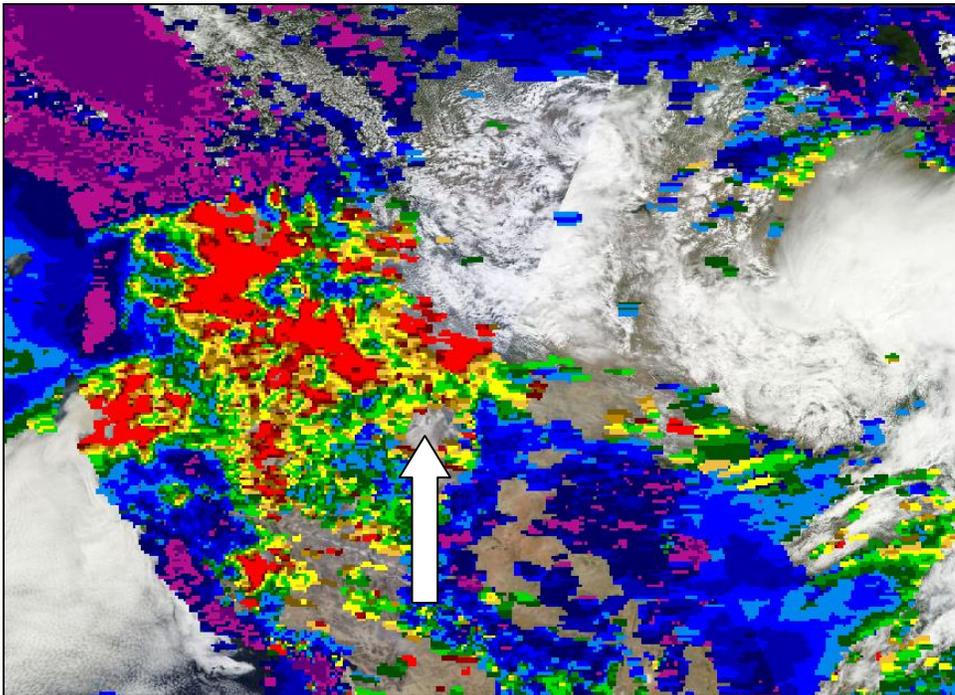
August 23, 2015



August 24, 2015

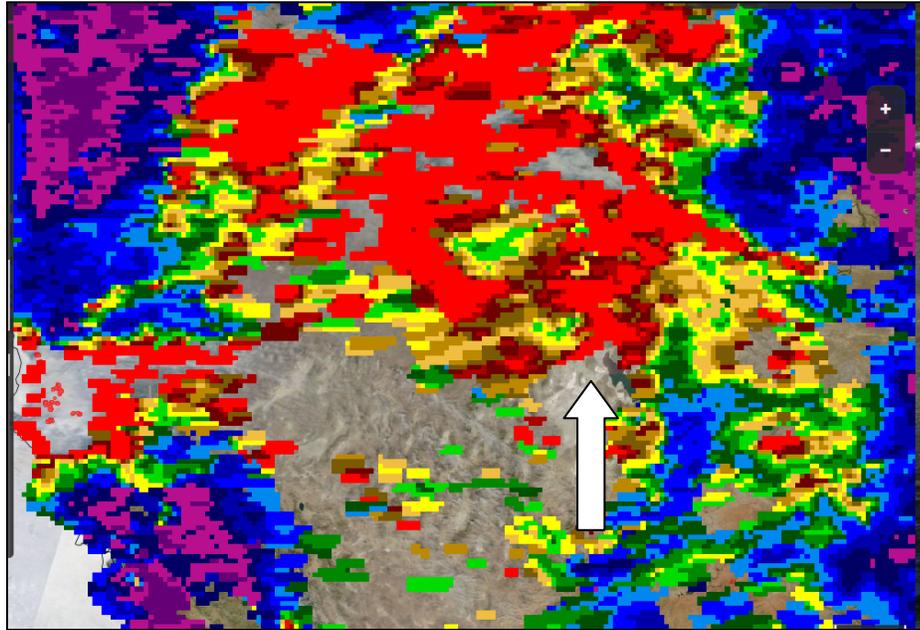
## Aerosol Optical Depth

Aerosol optical depth (AOD) measurements can provide supporting evidence of the presence of  $PM_{2.5}$  from smoke. AOD intensity is designated by a color code with blue being low AOD and red as the maximum AOD. The AOD overlay often masks geographic features that help us locate areas of interest. The Great Salt Lake Desert does not return an AOD signal, consequently it is used as a geographic marker on these images, designated by an arrow. The following AOD measurements were reported by NASA's Worldview.



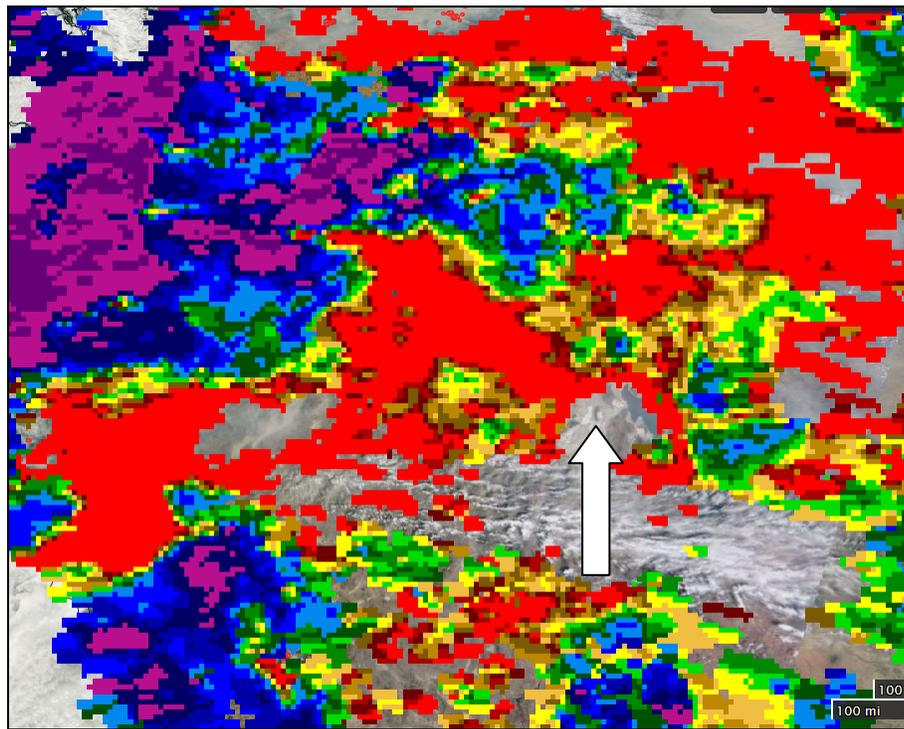
August 18, 2015

The wildfire hot spots are readily recognizable by the intensity of the red clustered areas. Varying degrees of AOD signal return is noted in Northern Utah (green to pink colors). This signal return is consistent with downwind smoke.



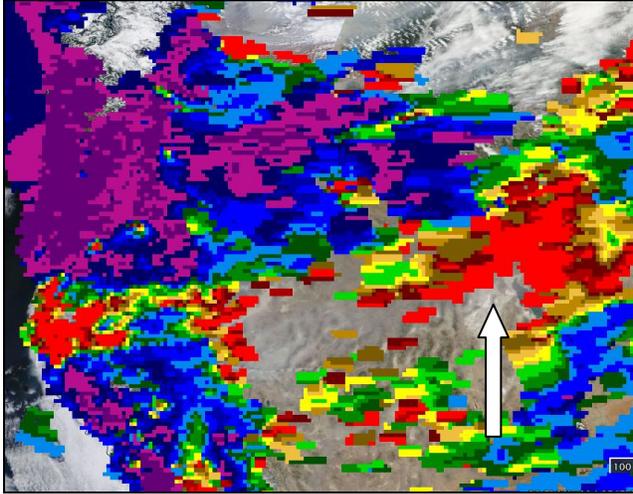
August 19, 2015

The AOD increased throughout Northern Utah (mostly red).

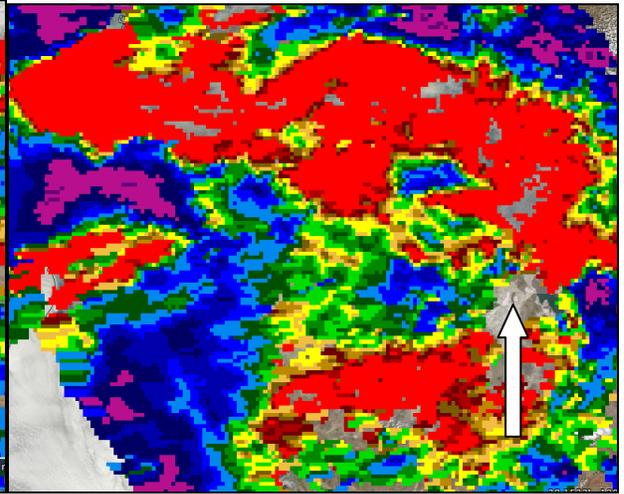


August 20, 2015

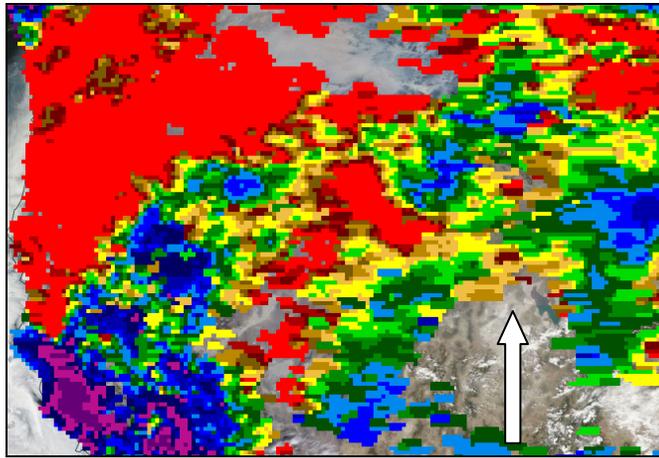
The AOD intensified throughout Northern Utah (all red).



August 21, 2015



August 22, 2015

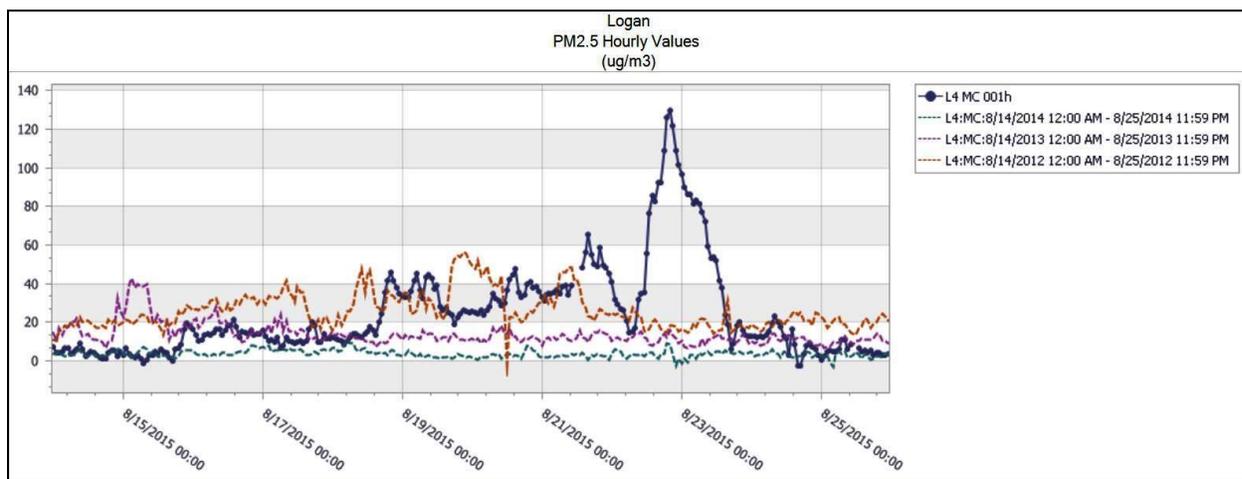
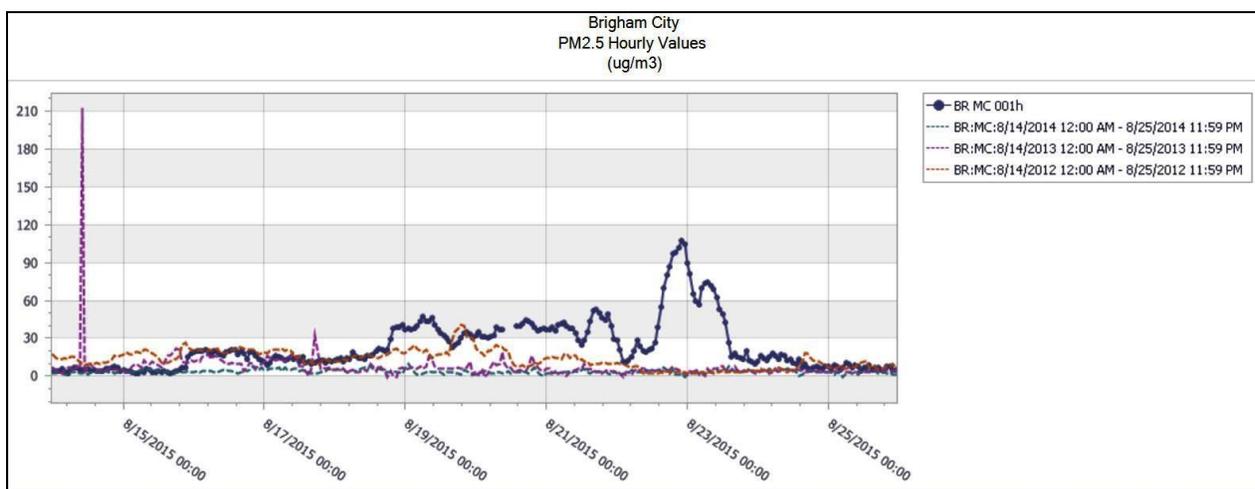


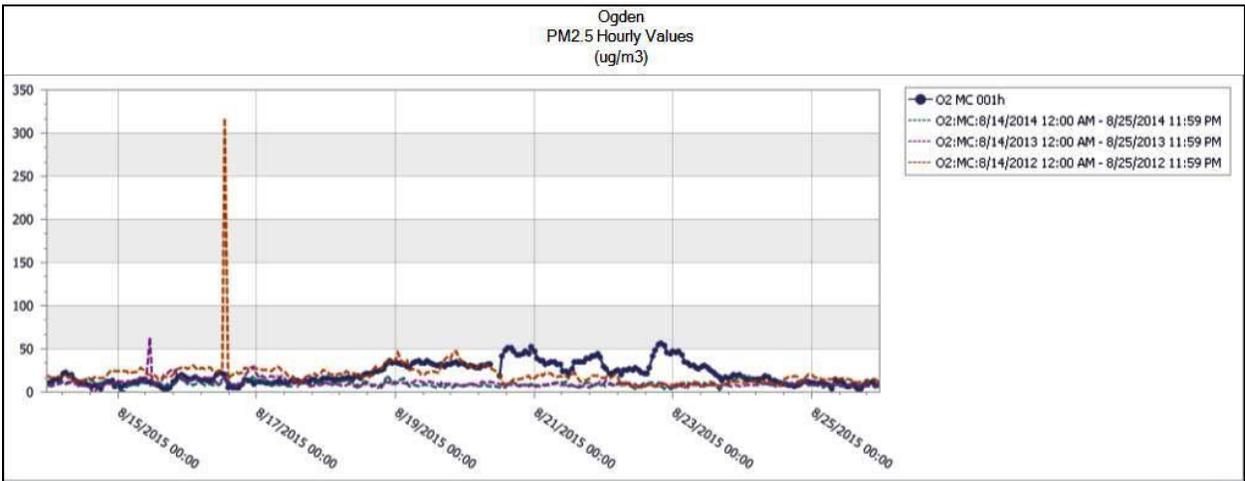
August 23, 2015

## Historical Fluctuation

Four years of historical hourly values corresponding to the time before the smoke arrived on August 15, 2015 to the dispersion of the smoke on August 25, 2015.

The 2015 data is shown in blue for each monitoring station. Past western wildfire influences occurred on August 15 and 19, 2013.

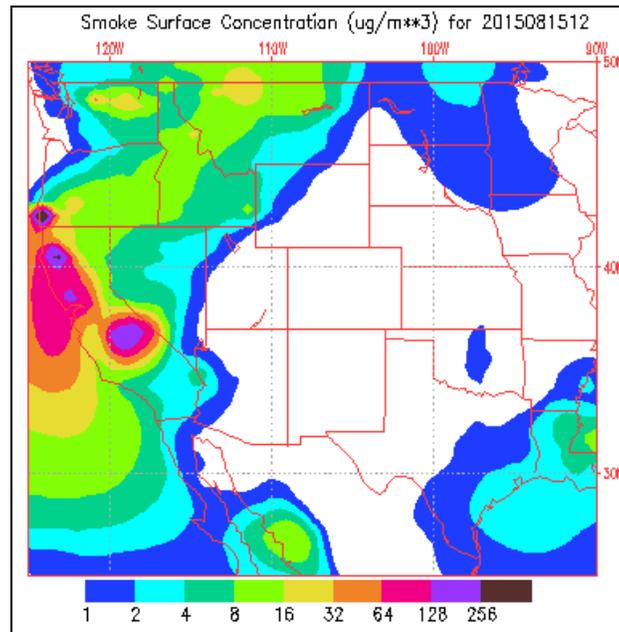




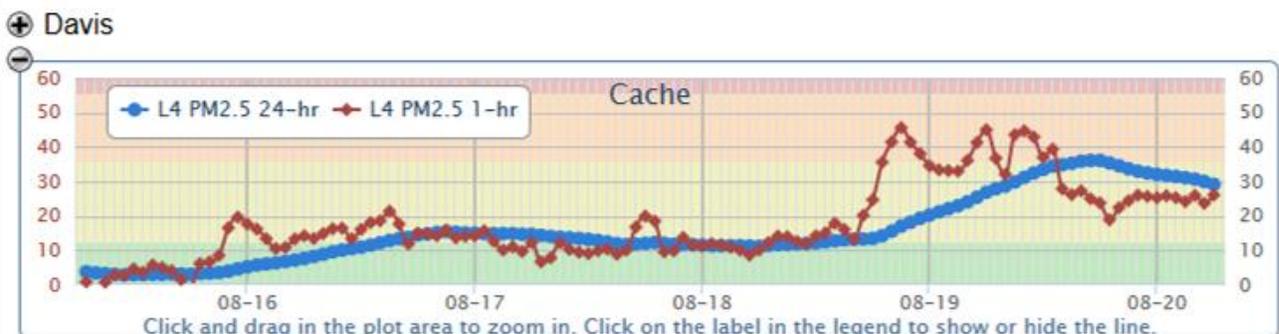
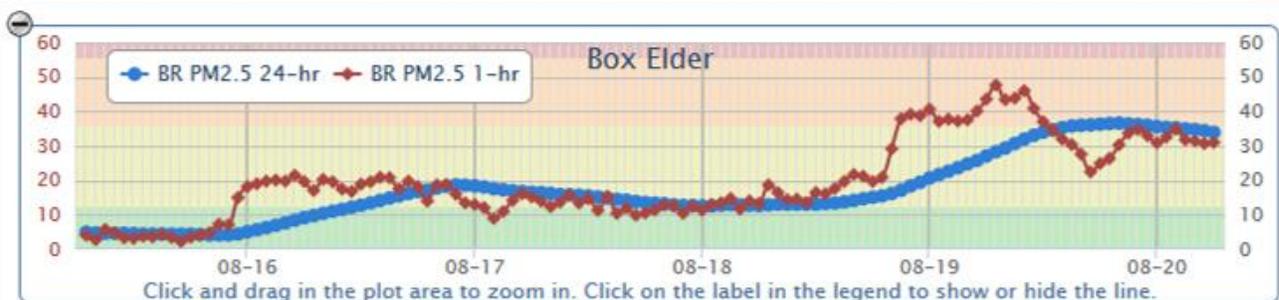
# No Exceedance But For the Event

## Wildfire Apportionment

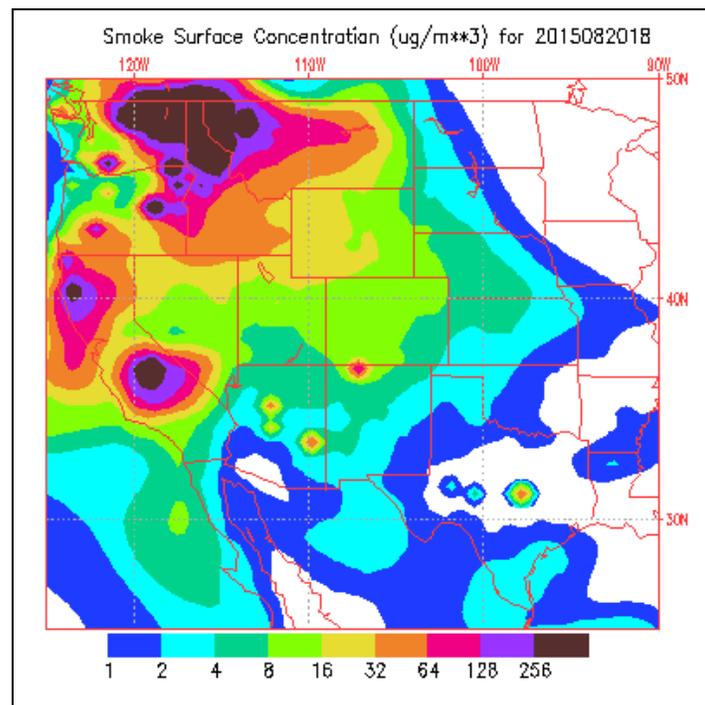
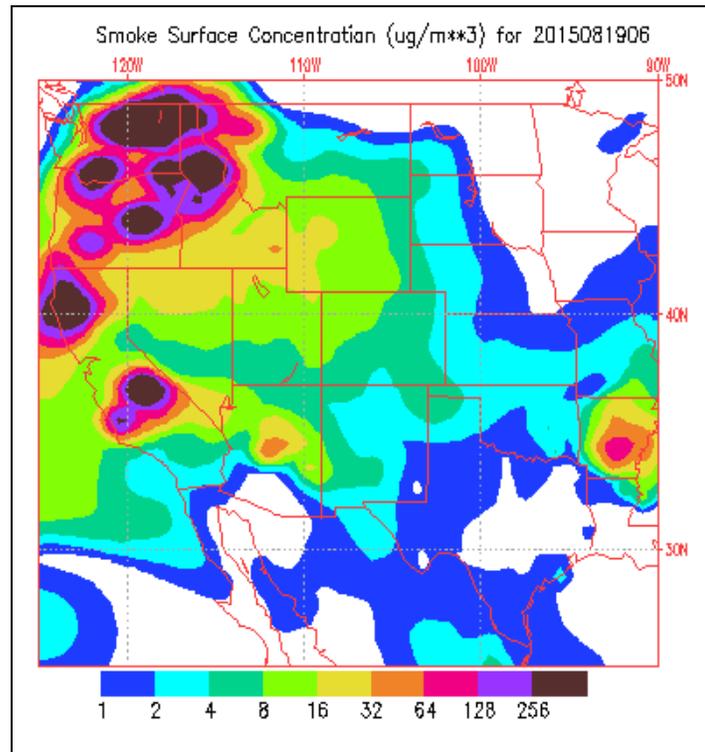
The Naval Aerosol Analysis and Prediction System (NAAPS) provides an estimate of smoke surface concentrations. According to NAAPS, the first smoke migrated to the surface in Northern Utah on the morning of the 15<sup>th</sup>, as shown on the NAAPS surface smoke map.



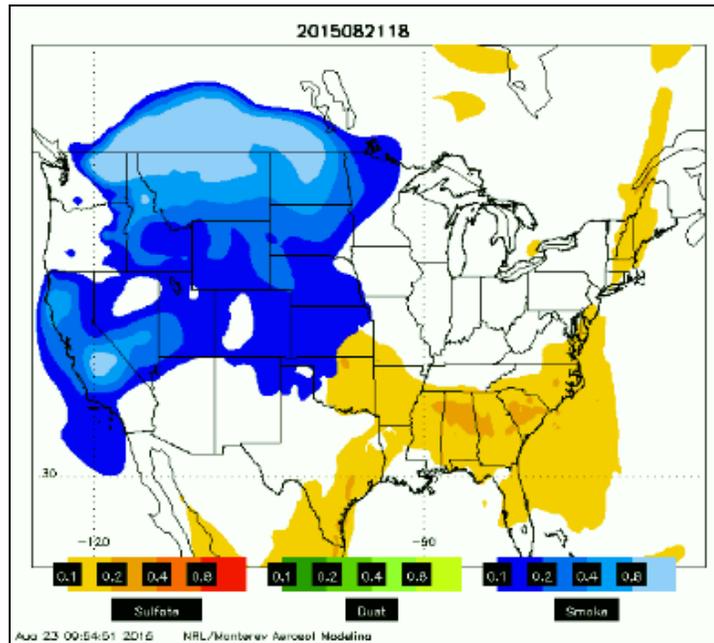
Monitoring data indicates that the smoke first migrated to the surface on the 15<sup>th</sup> between 8-10 p.m., as shown on the trend chart.



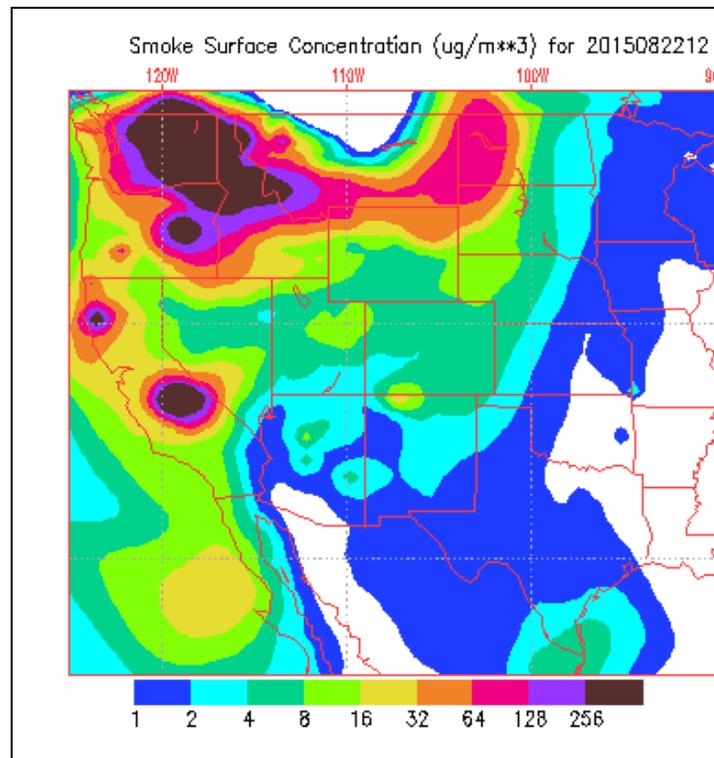
NAAPS ground smoke contribution projections for August 19-20, 2015 ranged from 8-32  $\mu\text{g}/\text{m}^3$  in northern Utah.

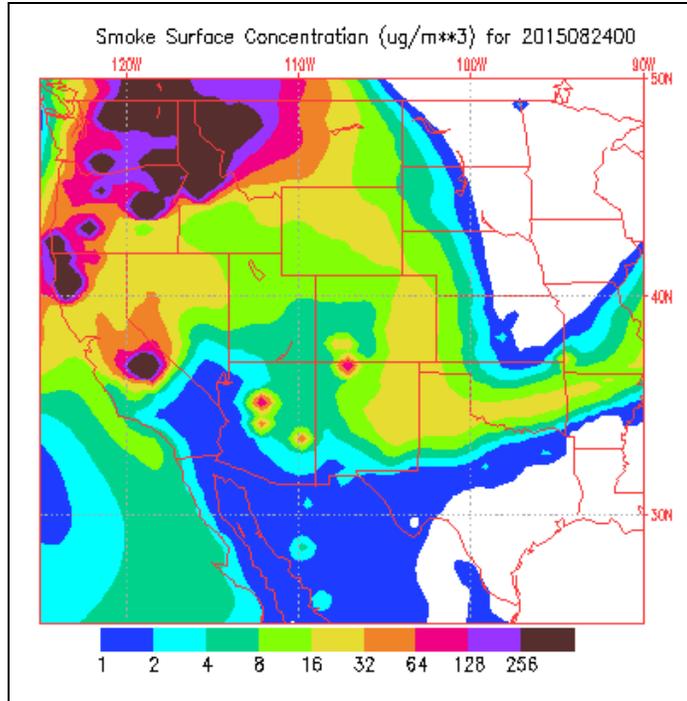
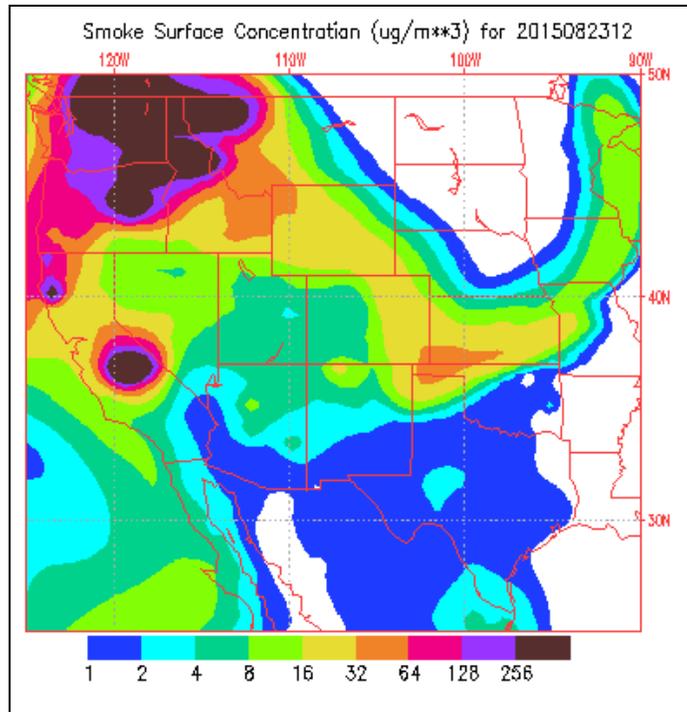


NAAPS ground smoke contribution projections for August 21, 2015 indicated high levels (dark blue) in northern Utah.



NAAPS ground smoke contribution projections for August 22-24, 2015 ranged from 4-16  $\mu\text{g}/\text{m}^3$  in northern Utah.





The summer of 2011 was a low wildfire year therefore, we can compare monthly values from that period to the current event for each monitoring station. Subtracting the monthly means from the maximum values for each monitoring stations, we see that the smoke contributed as much as 56  $\mu\text{g}/\text{m}^3$  at the Logan station.

	Brigham City	Logan	Ogden
August 2011 Arithmetic Mean ( $\mu\text{g}/\text{m}^3$ )	7.8	6.9	8
August 2011 Standard Deviation	3.4	2.5	2.9
Maximum August 2015 Value ( $\mu\text{g}/\text{m}^3$ )	46.8	62.9	38.3
Net Maximum Smoke Contribution ( $\mu\text{g}/\text{m}^3$ )	<b>39</b>	<b>56</b>	<b>30.3</b>

### ***Anthropogenic sources***

There were no other known anthropogenic sources other than the western wildfires during the event days that could contribute to these levels of  $\text{PM}_{2.5}$  increases across the entire northern Utah region.

### **Reasonable Controls**

The Exceptional Events Rule requires that states have in place reasonable controls during exceptional events. The western wildfires were located outside of the State of Utah, beyond Utah control. None the less, the DAQ smoke management plan includes regulations that address open burning, prescribed burning and wildfire management.

- R307-202. Emission Standards: General Burning. This rule regulates when general burning can be conducted under permits issued by local fire authorities. Open burning periods are established in different parts of the state when the atmosphere can safely disperse smoke and when wildfire hazard is low. This rule also prohibits the burning of certain materials.
- R307-204. Emission Standards: Smoke Management. This rule is designed to mitigate the impact on public health of prescribed fires and wildfires by establishing strict requirements of land owners, state and federal agencies that conduct prescribed fires and actions necessary by the wildfire coordinators during a wildfire event. The state smoke manager (a Bureau of Land Management employee) processes all prescribed fire requests prior to submitting those requests for DAQ director approval. He assures that prescribed fire plans contain a smoke mitigation plan and that the burn will comply with R307-204.

The Department of Natural Resources has fire management jurisdiction in unincorporated and forest lands through R652-120.

- R652-120. Wildland Fire. The State Forester enforces open burning of yard waste through a burn permit in unincorporated lands in the same manner as R307-202 which is designed for incorporated lands. This rule also deals with fire management and suppression and prescribed fire management.

## Mitigation

1. News releases during the event advised citizens of the potential health impacts of smoke from the wildfires.
2. Web sites about emissions from wildfire are posted on the DEQ web site. They cover the health impacts of PM and actions a person could take to minimize exposure to PM.

## Conclusions

1. The violations of the PM<sub>2.5</sub> 24-hr standard would have not occurred but for the wildfire smoke. A weight of evidence approach was used in this documentation to support that conclusion by applying analysis of satellite imagery, remote sensing tools and historical comparisons.
2. Wildfire smoke contributed up to an estimated 56 µg/m<sup>3</sup> of PM<sub>2.5</sub>.
3. There were no other known anthropogenic sources other than the western wildfires during the event days that could contribute to these levels of PM<sub>2.5</sub> across northern Utah.
4. Reasonable controls are in place and no foreseeable measures could be put into place to avoid or control naturally derived wildfires. Further, the wildfires were located outside Utah jurisdictional boundaries.
5. This documentation supports the exclusion of the violations under the Exceptional Events Rule.